contents

Highlights 1 1/A9
  Trends 1 1/A9
  Future Directions 1 1/A9
Introduction 2 1/A10
Overview 3 1/A11
Factors Behind Growth in Academic S/E Professional Employment 4 1/A12
Institutional Distribution of Research 6 1/A14
Changing Employment Characteristics of Academic Researchers 8 1/B2
Women Scientists in Academe 9 1/B3
Toward the Future 10 1/B4
Summary 12 1/B6

Appendix:

  Technical Notes 14 1/B8

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employment patterns of academic scientists and engineers 1973-78

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foreword

Academic science is the product of many factors; consequently, explanation of the behavior of the academic science system is not simple and the apparent relationship of factors may, at first glance, be baffling. One of such cases is the main topic of this report, namely, the continued increase in the number of academically employed scientists and engineers in the face of financial constraints. Questions which are addressed include: What were the characteristics of the science and engineering (S/E) growth in academe? Why did institutions continue to increase S/E employment in light of pending demographic shifts in the college-age population? What might be some of the consequences of these growth patterns? The analyses presented are based on data from the National Science Foundation's academic science surveys and extensive interviews of university officials at 23 institutions. It is hoped that the picture that has emerged from these studies will provide a better understanding of academic employment practices and will be useful to both the institutions and the Federal Government in shaping future decisions.

Charles E. Falk
Director, Division of Science
  Resources Studies
Directorate for Scientific, Technological,
  and International Affairs

July 1980

notes

The primary data sources used in this report are from three annual surveys of academic institutions conducted by NSF that concern S/E professionals, R&D expenditures, and graduate S/E students and postdoctorates.

For a more detailed description of the institutional sample design and selection, see the technical notes at the end of this report.

For information on the availability of data tapes, contact Moshman Associates, Inc., 6400 Goldsboro Road, Washington, D.C. 20034, or telephone 301-229-3000.

acknowledgments

This report was prepared in NSF's Division of Science Resources Studies, Charles E. Falk, Division Director. The principal author was Richard M. Berry, Study Director, Universities and Nonprofit Institutions Studies Group. Site visits to a sample of institutions of higher education were conducted by three NSF staff members: Richard M. Berry, James B. Hoehn, and Susan G. Broyles. Nathan Dickmeyer of the American Council on Education assisted in conducting the field interviews under contract with NSF. William L. Stewart, Head of the R&D Economic Studies Section, provided general guidance and review. The report could not have been prepared without excellent cooperation from university officials who served as respondents to NSF's annual surveys of academic science resources statistics and especially those officials who participated in the field interviews.

contents

Highlights 1
  Trends 1
  Future Directions 1
Introduction 2
Overview 3
Factors Behind Growth in Academic S/E Professional Employment 4
Institutional Distribution of Research 6
Changing Employment Characteristics of Academic Researchers 8
Women Scientists in Academe 9
Toward the Future 10
Summary 12
Appendix:
  Technical Notes 14

highlights

trends

- Recent increases in academic employment of S/E professionals, averaging around 3 percent annually, have been concentrated in doctorate-granting universities. These universities accounted for almost two-thirds of the net growth in academic scientists and engineers during 1973-78.

- In field interviews the reason most prominently mentioned by institutional officials for the growth of S/E professionals was increased research support. R&D expenditures at doctorate-granting institutions rose by more than 57 percent during 1973-78, or by more than 9 percent in real terms; federally funded R&D activities at these institutions increased by 4 percent in real dollars. As a result of such growth in R&D expenditures, full-time-equivalent (FTE) involvement in R&D activities by academic scientists and engineers increased at double the rate of their involvement in teaching and other activities.

- Employment of scientists and engineers grew fastest, or over 3 percent annually, during 1973-78, in doctorate institutions outside the "distinguished" category of Ladd-Lipset rankings of U.S. universities. Most of the growth was attributable to the institutions' augmenting their S/E staff in attempts to achieve educational excellence by launching new or improved graduate and research programs. Rates of growth in Federal research funding to universities outside the top 100 doctorate recipients (ranked by Federal R&D support) exceeded by more than 50 percent those shown for the top 10 universities.

- For "distinguished" research institutions the factors most frequently mentioned behind S/E employment growth during the seventies were (1) Absence of a need to hedge against pending demographic shifts because of strong demand for both undergraduate and graduate education in the sciences and engineering; and, (2) Confidence in the ability of the institution to continue attracting Federal and other outside support for research projects.

- With respect to hiring practices, research is playing a greater role in most institutions in the selection of new S/E staff. Not only is research viewed as an activity providing the primary means of upgrading the quality of institutions and departments, it is also an increasingly important source of revenue. By 1978 research comprised almost one-fifth of total education and general income at universities. Selection committees charged with recommending new S/E hires increasingly select applicants with research experience. Also, there is an increasing tendency to hire new scientists and engineers on nontenure tracks, with renewal of short-term contracts dependent on their ability to continue to attract external support.

- Women accounted for almost one-third of the net 1974-78 growth in employment of full-time academic scientists and engineers. Women scientists and engineers employed full time by doctorate-granting institutions increased by about three times the rate of men during this period. However, results of the field interviews confirmed the findings of other recent studies that many of these women were hired under short-term arrangements supported by research grants and contracts. According to university officials interviewed, this practice helped to achieve dual objectives—one relating to affirmative action and another tied to overall financial solvency.

future directions

- Officials interviewed at the "distinguished" Ladd-Lipset institutions expressed optimism about the future. They believe that the projected decline in U.S. college enrollments will have little, if any, effect on their institutions because of a continuing demand for educational quality by student applicants.

- The most vulnerable institutions are those outside the "distinguished" category that pushed to upgrade quality by launching new research and graduate programs. These same institutions hired relatively large numbers of investigators who exist on "soft money" from Federal agencies and other outside sponsors. They are especially exposed to expected future adversity resulting from shifting demographic patterns impacting on the college-age population.

introduction

Most of the statistical analysis contained in this report is based on special tabulations of data on employment of scientists and engineers, R&D expenditures, graduate science student enrollment, and utilization of postdoctorates in 271 institutions granting the doctoral degree. Because data shown here are limited to matched comparisons in these institutions, they do not agree with statistics contained in other National Science Foundation (NSF) publications covering various characteristics of academic science in all universities and colleges.

The data have been supplemented by interviews of academic officials at a sample of 23 institutions. These 23 institutions accounted for 15 percent of all academic S/E employment in 1978 and 18 percent of the net growth in all scientists and engineers in academe during 1973-78. For the most part, the institutions selected for interviews were among the highest ranked in terms of S/E employment growth in the seventies. They are not statistically representative of all universities and colleges in the country since only two institutions with S/E personnel declines during the study period were in the sample. These two were included to contrast with the others where professional S/E employment increased.

The topics addressed in this report center around the continual increases in employment of academic scientists and engineers even though numerous studies claim that fiscal constraints exist in much of the higher education sector.[1] According to these studies, universities are caught in a financial vise because income from both public and private sources has not been rising at sufficient rates to balance costs which have been escalating sharply because of several factors, notably inflation.

During periods of financial adversity, conventional economic wisdom calls for reductions in employment. This would seem to be particularly true for universities and colleges where wages and salaries comprise the largest proportion of total expenditures. For example, a typical institution may expend about three-fourths of its total current funds for wages and salaries. Thus, this study was designed to identify factors that would explain why academic administrators continued to hire additional scientists and engineers when faced with present conditions of financial adversity and when higher education is entering a period where enrollment declines may make the fiscal future even more uncertain.

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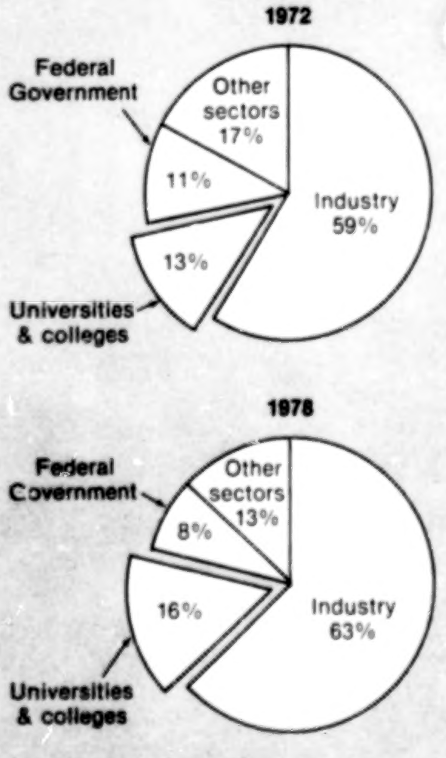
[1] For examples of such studies see: Ford Foundation, *Research Universities and the National Interests: A Report from Fifteen University Presidents* (New York, 1978.) L.R. Smith and Joseph J. Karlesky, *The Universities in the Nations Research Effort* (New Rochelle, N.Y.: Change Magazine Press, 1977.) David W. Breneman, *Graduate School Adjustments to the New Depression in Higher Education* (Washington, D.C.: National Academy of Sciences, National Board on Graduate Education, 1975.)

overview

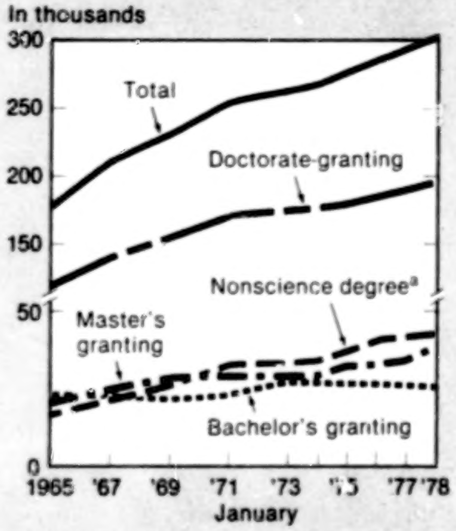
Although their numbers are relatively small in relation to national totals, academic scientists and engineers play a special role in the performance of basic research and in the education and training of future generations of scientists and engineers. More than one-half the Nation's basic research performance, as measured by expenditures, is carried out by academic scientists and engineers and nearly three-fifths of the total, if university-administered federally funded research and development centers (FFRDC's) are included. These figures understate the actual amounts spent on basic research in the academic sector since work on activities carried out as departmental research cannot be reliably measured because it is an inextricable part of instructional accounts.

Chart 1. Employment of scientists and engineers in the United States: 1972 and 1978



SOURCE: National Science Foundation

Chart 2. Scientists and engineers employed at universities and colleges by type of institution



^a Includes 2-year institutions.
SOURCE: National Science Foundation

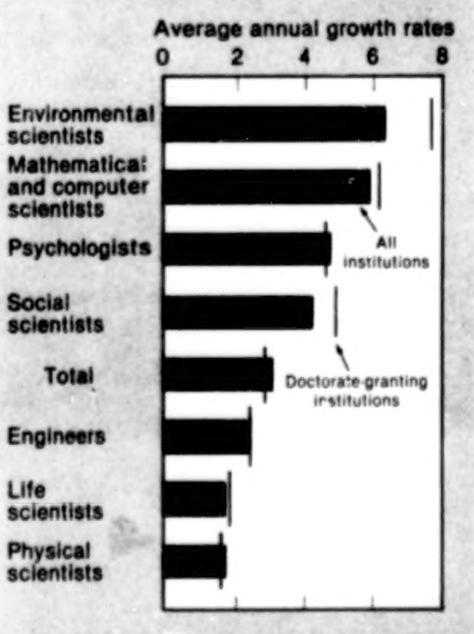
A total of 306,500 professional scientists and engineers were employed in U.S. universities and colleges in 1978, accounting for one of eight in all sectors of the economy. For the 6-year period beginning in 1972, both academia and industry slightly increased their shares of the national total of S/E employment (chart 1).

Annual increases in professional S/E employment in all universities and colleges averaged 3 percent during 1973-78. Although these growth rates are half those occurring in the 1965-73 period, questions remain about how and why institutions continued to augment their professional S/E staffs. What categories of institutions accounted for recent growth in academic scientists and engineers? Did these institutional growth patterns reflect administrative reaction to financial constraints revealed in a number of studies?

As shown in chart 2, the total 1965-78 growth of academic S/E professionals occurred primarily in doctorate-granting institutions (63 percent). By comparison, only 20 percent of the increase occurred in nonscience degree-granting institutions, 14 percent in master's institutions, and just 3 percent in institutions granting only the bachelor's degree.

Because doctorate-granting universities were dominant, growth rates for all institutions are similar to those of Ph.D.-granting universities. The largest rates of growth were observed for environmental scientists and mathematical and computer scientists (chart 3).

Chart 3. Scientists and engineers employed at universities and colleges by area of science: 1973 to 1978

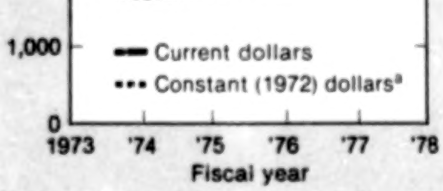


SOURCE: National Science Foundation

factors behind growth in academic s/e professional employment

Field interviews at 14 of the 23 sampled institutions indicated that increases in research funds were primarily responsible for most of the increased employment of scientists and engineers. The factors motivating the hiring of regular, tenure-track faculty at these institutions were not necessarily the same ones behind the hiring of scientists and engineers employed from year to year as researchers. For regular faculty, the level of enrollments was, in general, the most important factor determining hiring requirements. For researchers, success in obtaining outside support was most often cited as the major determining factor. While many institutions in the sample were in the Ladd-Lipset "distinguished" category, there are indications that this emphasis on research is widespread among all doctorate-granting institutions, as the less prestigious institutions strive to gain reputations for academic excellence by launching new research and graduate programs and upgrading existing ones. "Distinguished" institutions were identified in a survey conducted by Everett C. Ladd, Jr. and Seymour Martin Lipset in which respondents were asked ". . . to name the five departments that have the most distinguished faculties," in the order of their importance in 1977. Distinguished institutions were considered in the Ladd-Lipset study as those that were rated among the top five in each discipline, including those classified as science and engineering, by at least 10 percent of the respondents in each of 19 fields.[2]

Chart 4. R&D expenditures in the sciences and engineering at doctorate-granting universities



[a]Based on GNP implicit price deflator.
SOURCE: National Science Foundation

Data on academic R&D expenditures support the observation of the inter-

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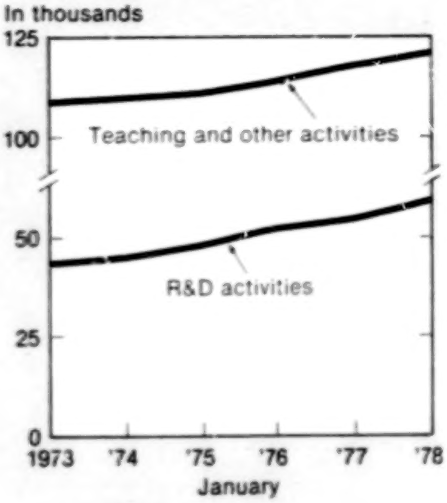
Ten of the 23 institutions in the field interview sample were classified as "distinguished" in a study conducted by Everett Ladd and Seymour Lipset. See the *Chronicle of Higher Education*, Jan. 15, 1979.

Chart 5. Scientists and engineers employed at doctorate-granting universities by FTE[a] involvement in R&D activities and teaching and other activities

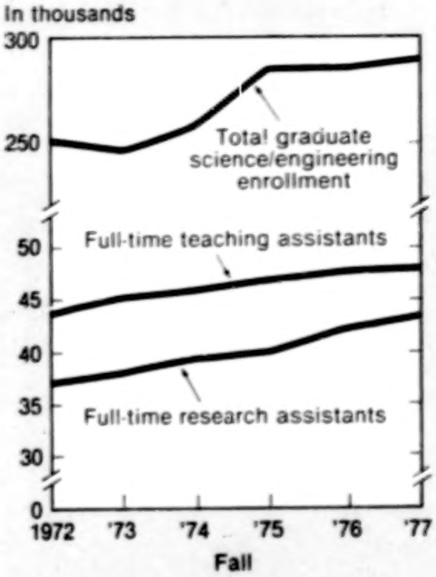


[a]Full-time-equivalent.
SOURCE: National Science Foundation

viewees on greater emphasis on research funding as a support mechanism for S/E professionals. R&D expenditures of doctorate-granting institutions increased by more than 57 percent during 1973-78, or more than 9 percent after adjusting for inflation (chart 4). Federal R&D funding at these institutions went up 50 percent during the 5-year period, or 4 percent in real terms. As a result of this growth in R&D expenditures, the number of FTE S/E professionals involved in academic R&D activities in doctorate-granting institutions increased at twice the rate (22 percent) of those involved in teaching and other activities (11 percent) as shown in chart 5.

Another indicator of increasing R&D activity is growth in the number of graduate research assistants at doctorate-granting institutions, up from an estimated 37,200 in 1972 to 43,800 in 1977, an increase of 18 percent (chart 6). The number of teaching assistants increased at a lesser rate—10 percent over the same period

Chart 6. Graduate science/engineering enrollment at doctorate-granting universities by mechanisms of support[a]



[a]Totals for 1972 and 1973 are estimates based on NSF survey data, as explained in the technical notes.
SOURCE: National Science Foundation

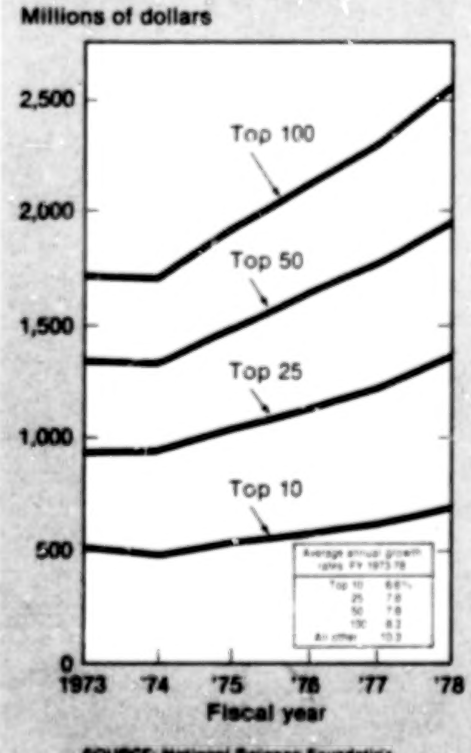
institutional distribution of research

During the 1973-78 period Federal academic R&D funding has grown at higher rates in institutions outside the top 100 recipients (chart 7). These distribution patterns reflect national policies for wider institutional and geographic dispersion. Accordingly, annual growth rates during 1973-78 in Federal R&D funds to doctorate-granting institutions outside the top 100 recipients were over 10 percent, compared with 7 percent for the top 10 institutions and around 8 percent for all others in the top 100.

Partly as a result of wider distribution of Federal funds, research is being utilized by some of the less prestigious doctorate-granting institutions as a vehicle to upgrade their reputations for scholarly excellence. These institutions reported average annual rates of growth in S/E employment during 1973-78 that exceeded the rates of "distinguished" institutions (3 percent vs. 1 percent). These institutions, along with their total and federally funded R&D expenditures are shown in table 1.

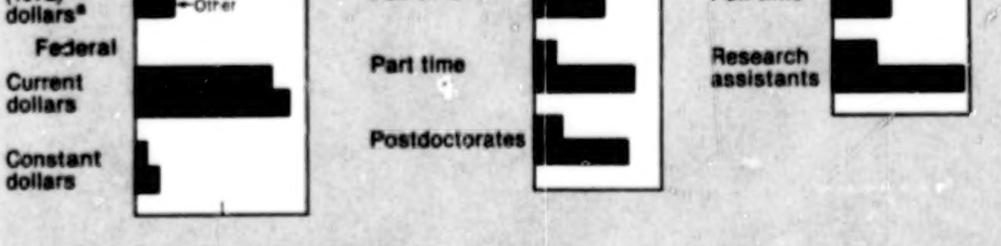
The 33 "distinguished" institutions accounted for 44 percent of total academic R&D expenditures by doctorate-granting institutions and slightly more of total federally funded R&D supported in academe in 1978. However, institutions outside the "distinguished" grouping (henceforth, called "other") experienced larger rates of growth during 1973-78 (chart 8). These "other" doctorate-granting institutions experienced average annual growth rates for total R&D expenditures of 10 percent in current dollars, compared with 9 percent for the "distinguished" grouping. The higher growth rates of the "other" category were driven by Federal funding of R&D activities, which increased by 9 percent annually during 1973-78, in comparison with 8 percent in the "distinguished" institutions. The total number of graduate science students in institutions in the "other" category grew at more than twice the rate of the "distinguished" institutions and utilization of research assistants and postdoctorates grew about three times greater in "other" institutions.

Chart 7. Concentration of federally financed R&D expenditures at doctorate-granting institutions



SOURCE: National Science Foundation

Chart 8. "Distinguished institutions" compared with "other" doctorate-granting institutions: 1973 to 1978.



*Based on GNP implicit price deflator.
SOURCE: National Science Foundation

Table 1. Total and federally financed R&D expenditures at "distinguished" institutions: FY 1978[1]

[Dollars in thousands]

Distinguished institutions ranked by total R&D expenditures	Total	Federally financed
Total	$1,984,389	$1,364,445
1 Mass Inst of Technology	119,620	102,131
2 Univ of Wisconsin-Madison	107,939	68,870
3 University of Minnesota	94,706	53,265
4 University of Washington	89,014	74,927
5 Stanford University	88,198	78,706
6 University of Michigan	86,886	58,436
7 Harvard University	84,150E	63,687
8 Cornell University	83,380	54,730
9 Univ of Pennsylvania	76,493	52,399
10 Columbia Univ Main Div	74,619	59,862
Total 1st 10 Institutions	905,005	667,013
11 Univ Illinois, Urbana	73,850	42,019
12 U of Cal Los Angeles	72,279	57,991
13 U of Cal Berkeley	70,307	49,791
14 Johns Hopkins University	59,594	25,123
15 Texas A&M University	65,249	53,777
16 University of Chicago	58,105	44,197
17 U of Cal San Francisco	56,584	46,740
18 Michigan State University	55,438	24,539
19 Yale University	53,521	47,212
20 U of Cal Davis	51,440	25,483
Total 1st 20 Institutions	1,521,372	1,083,885
21 Ohio State University	50,953	26,877
22 Washington University	48,256	38,301
23 Purdue Univ All Campuses	48,049	30,059
24 Iowa St U of Sci & Tech	39,947	12,884
25 Colorado State University	34,615	25,014
26 Oregon State University	34,464	18,757
27 Rockefeller University	33,703	15,432
28 Duke University	33,491	28,264
29 N C State Univ at Raleigh	32,908	10,800
30 Univ of NC at Chapel Hill	29,277	23,194
Total 1st 30 Institutions	1,907,035	1,313,467
31 California Inst of Tech	28,433	24,985
32 Univ of Nebraska-Lincoln	25,521	8,040
33 Princeton University	23,400	17,953

[1] These "distinguished" institutions were identified in a survey conducted by Everett C. Ladd, Jr. and Seymour Martin Lipset.

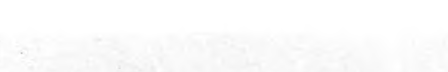
NOTE: "E" denotes estimated amount by NSF.

SOURCE: National Science Foundation

changing employment chacteristics of academic researchers

There are indications, borne out by the campus interviews and supported by other studies, that emphasis on sponsored research influences institutional recruitment policies and practices. For example, a study carried out by the National Research Council (NRC) found that large research-oriented universities are expanding their utilization of nonfaculty research personnel, especially physical and biological scientists.[3] Included in this group are postdoctoral appointees, doctoral research staff, and other nonfaculty staff primarily involved in research. NSF data on postdoctoral utilization confirm one of these findings. Postdoctoral utilization by doctorate-granting institutions increased by 11 percent between 1972 and 1977 (chart 9). By 1977, the 19,700 postdoctorates in these institutions represented about one-tenth of the total academic S/E professionals.

Chart 9. Postdoctorates utilized in the sciences and engineering at doctorate-granting institutions[a]



[a]Totals for 1972 and 1973 are estimates based on NSF survey data, as explained in the technical notes.
SOURCE: National Science Foundation

A recent study of nonfaculty research staff found that, between 1975 and 1977, the numbers of academic employees holding these research staff positions increased by 20 percent, roughly 2½ times the faculty growth rate.[4] Another related study reported that in 1977, departments of medicine accounted for 40 percent of nontenure-track personnel, with chemistry (19 percent), biochemistry (13 percent), and biology (12 percent) also having relatively large numbers.[5]

The field interviews showed that a number of institutions are making academic appointments on a year-to-year basis contingent on the ability of newly hired scientists and engineers to bring in sponsored research funds. Committees charged with recommending new hires among scientists and engineers increasingly based their selection criteria on the applicant's ability to attract outside research support. Renewal of short-term contracts of these researchers often depends on their continuing ability to attract external support.

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[3] National Research Council, Commission on Human Resources, *Nonfaculty Doctoral Research Staff in Science and Engineering in United States Universities* (Washington, D.C., 1978.)

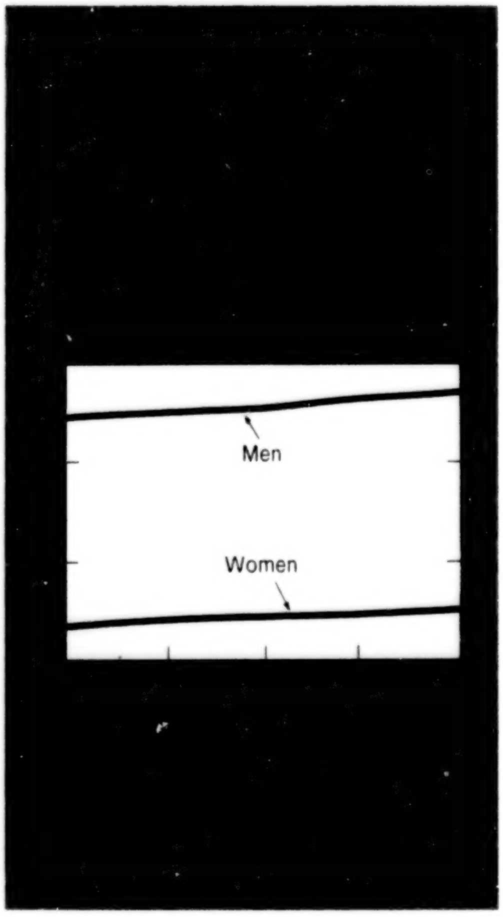
[4] Ibid.

[5] American Council on Education, "Nontenure-Track Science Personnel: Opportunities for Independent Research," *Higher Education Panel Reports*, No. 39, Sept. 1978.

women scientists in academe

All institutions in the field study had affirmative action programs, and in most cases these procedures were the only central attempt to control faculty hiring. There are indications from NSF data that equity considerations are influencing the numbers and characteristics of newly employed academic S/E professionals.[6] For example, female scientists and engineers employed full time, although accounting for only 15 percent of full-time academic S/E professionals, accounted for almost one-third of the net growth in full-time employment during 1974-78 and increased almost three times as fast as males (chart 10).

Women accounted for all of the net growth in science faculty at the assistant professor level in the top 50 universities, ranked by Federal R&D obligations, and for nearly one-half the increase at all other institutions.[7] Evidence points to the fact, moreover, that many women are being recruited into nonfaculty research positions. Another study, carried out under an NSF grant, concluded that while the number of women scientists and engineers employed full time increased rapidly in the seventies, new female entrants tended to be in nontenured positions and in a limited number of scientific fields.[8] Also, the NRC study of nonfaculty doctoral researchers cited previously found that women were recruited for these positions in relatively large numbers in the fields of psychology, biosciences, and the social sciences.[9] A related survey of academe in 1977 revealed that about one-fifth of nontenure-track faculty and staff were women.[10]



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[6] Clare Rose, Sally Menninger, and Glenn Nyre, *The Study of the Academic Employment and Graduate Enrollment Patterns and Trends of Women in Science and Engineering*, conducted for NSF under grants Nos. SRS 76-82705 and 77-16927 (Los Angeles, Calif.: Evaluation and Testing Institute, 1978).

[7] National Research council, Committee on Human Resources, *Climbing the Academic Ladder: Doctoral Women Scientists in Academe* (Washington, D.C., 1979.)

[8] Clare Rose, et. al., op. cit.

[9] National Research Council, Commission on Human Resources, *Nonfaculty Doctoral Research Staff in Science and Engineering in United States Universities*, op. cit.

[10] American Council on Education, op. cit.

toward the future

Questions have recently been raised about the ability of academic institutions to recruit scientists and engineers in the face of rising costs resulting from inflation and reduced income caused by demographic shifts. In future years, income from undergraduate tuition, the most important determinant of faculty hiring, is expected to decline. The Census Bureau estimates that 1979 will be the peak year for the number of 18-year-olds in the U.S. population, the age group impacting most heavily on new entrants into higher education. According to these estimates the number of persons in the college-age groups is expected to drop about 18 percent over the 1979-86 period,[11] and that factor is expected to reduce the demand for professional employment in academe. Further evidence of a possible reduction in demand for academic scientists and engineers by doctorate institutions is the slowdown between 1975 and 1978 in the rate of growth of graduate S/E enrollment as illustrated earlier in chart 6. The slower, steadier pace during this period contrasts sharply with the expansion atmosphere of the early seventies and has been traced to higher tuition rates, a decline in the number of veterans enrolling in graduate programs, and an increase in job offers to bachelor's-degree holders—factors that affected both science and nonscience graduate programs.[12]

The concentration of S/E professional employment growth in doctorate-granting institutions explains partially why increases persist in light of expected demographic problems. A number of recent studies,[13] as well as information obtained in the field interviews, have shown that many of these doctorate-granting institutions, particularly those considered as "prestigious," are less susceptible to the full impact of declines in college enrollment than other institutions of higher education. Top administrators interviewed stated, with one exception, that the projected decline in U.S. college enrollments should have little, if any, impact on total enrollments at their institutions. Interviewees believed that their institutions' reputations should draw sufficient undergraduate and graduate applications in the sciences and engineering to maintain both tuition income and quality. The elevated position which these "prestigious" schools occupy is indicated by the current acceptance rates for admission: all had many more student applicants than they accepted as exemplified by one institution which currently accepts only 1 of 35 applicants in S/E programs. Additionally, several institutions had already established ceilings on student enrollments in S/E areas where future declines in student interests are expected and, in the opinion of the interviewees, these enrollment levels should be easily maintained.

These field interview findings were confirmed by a study conducted by NRC, under contract from NSF.[14] That study, while recognizing that enrollment growth is ending and demands for new faculty are going to fall, concluded that:

> "Expected declines in enrollment are one basis for predictions that new hires in academic science and engineering will fall over the next decade. But it is doubtful that these demographic effects will be felt with as much force at the major research institutions, which tend to have strong student markets relative to the rest of higher education. The major universities have not in the past had on the average as close a link between their faculty size and enrollment demographics as have other colleges and universities."

In terms of institutional finances and their impact on the hiring of scientists and engineers, the direct tie that exists between revenues and enrollment makes it difficult to separate the two because of the heavy reliance of many schools on tuition income. Field interviews showed, moreover, that for many institutions there is a considerable time lag between the initial impacts of financial adversity and forced reductions of scientists and engineers. Only one institution had undergone a period of financial problems significant enough to require reductions of S/E employment through attrition.

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[11] U.S. Department of Commerce, Bureau of the Census, "Projections of the Population of the United States: 1977 to 2050," Series P-25, No. 704 (Washington, D.C.: U.S. Government Printing Office, July 1977.)

[12] National Science Foundation, *Science Resources Studies Highlights*, "Graduate Science Enrollment in Doctorate-Granting Institutions Leveled Off in 1978" (NSF 79-321) (Washington, D.C., November 30, 1979.)

[13] National Research Council, *Research Excellence Through the Year 2000: The Importance of Maintaining a Flow of New Faculty into Academic Research*. A report with recommendations of the Committee on Continuity in Academic Research Performance (Washington, D.C., 1979.) Robert E. Klitgaard, *The Decline of the Best? An Analysis of the Relationship Between Declining Enrollments, Ph.D. Productions, and Research* (Cambridge, Mass.: Harvard University, May 1979.)

[14] Ibid.

When asked about the possibility of loss of financial vitality resulting from future downturns in enrollment, university officials observed that reductions in S/E faculty would only be resorted to as a last step indicating a "crisis state" in their institutions. Any budgetary squeeze would first cause such purchases as supplies to be cut. Then, acquisition of equipment replacement for items made obsolete by technological advances might be postponed. Next, technical, clerical, or administrative support staff might be reduced. Only after these measures are taken to reduce costs would regular faculty positions be cut back.

Nearly all of the top administrators interviewed, especially those in "distinguished" institutions, expressed confidence that a high demand for educational quality by undergraduate and graduate S/E students should continue into the foreseeable future and that because of this demand and the ensuing tuition income, a reduction in the number of scientists and engineers employed in their institutions was not likely. Other factors helping to guarantee adequate operating revenues were large endowments, the continuing ability to attract research support by the prestigious investigators on their faculty roles, and their established reputations for excellence in their graduate programs. The attitude of confidence expressed in these interviews, however, is probably not shared by all higher education officials, since the 23 sampled institutions consisted primarily of those with established reputations for educational excellence.

summary

Increases in S/E professional employment in academe have been concentrated in recent years in doctorate-granting institutions. These institutions, expecially major research universities with established reputations for educational excellence, continue to have strong student markets. Consequently, their hiring practices are not as directly dependent on enrollment demographics as are other institutions. Instead, increased R&D funding from both Federal and non-Federal sources seems to have been the principal factor responsible for recent growth in employment of academic scientists and engineers.

Research is being increasingly emphasized as a means of attracting support for S/E professional staff. Rates of growth of S/E professional employment have been highest in doctorate-granting universities outside the "distinguished" category of institutions. For many of these institutions, research, combined with graduate programs, is a means of attaining scholarly excellence. The funding policies of Federal agencies, the main source of academic research support, are producing faster rates of growth in institutions outside the top 100 recipients of federally funded R&D activities. Research emphasis is also influencing the types of positions offered to applicants for S/E jobs. Many institutions are basing their hiring decisions on the applicants' ability to attract outside monies in support of research projects. Renewal of contracts on a year-to-year basis is contingent on the continuing availability of sponsored research funds, primarily those from Federal agencies.

Institutions in the lower quartiles of research performance are expected to be relatively vulnerable to financial adversity resulting from high rates of inflation and demographic shifts caused by anticipated declines in the college-age population. S/E personnel on short-term renewable research contracts, including many of the newly recruited women scientists, are expected to be especially vulnerable to any future reductions in force necessitated by combinations of economic and demographic factors and any real decreases in Federal R&D support.

appendix

technical notes

appendix

technical notes

General Methodology

This special study is based on structured interviews with university administrators and officials at 14 public and 9 private doctorate-granting institutions. Thirteen of these interviews were conducted by NSF representatives and 10 by an American Council on Education official working under contract to NSF. Structured interview guidelines were developed by NSF.

One individual on each of the 23 campuses served as coordinator for the study. Generally, the coordinator was located in a central position in terms of data systems, planning, or research administration. A letter was sent to the campus coordinators outlining the purpose of the study and requesting participation in setting up interviews with administrators and faculty. At least one full day, and in most cases two days, were spent at each institution for interviews. Before the campus visits, coordinators were provided with institutional profiles containing NSF personnel survey data for the 1973-78 period and with structured interview guidelines to be distributed to interviewees. The positions of the interviewees varied but included presidents, vice presidents for research administration, personnel directors, graduate deans, and institutional researchers.

Sample Selection

The size of the institutional sample was based on both cost and time factors, as well as analytical and sampling considerations. To maximize cost/benefit considerations, the institutional sample was selected from a list of institutions reporting the largest increases in professional employment during the study period 1973 through 1978. In addition, two institutions that had reported declining employment levels were selected.

The universities visited during this study employed 15 percent of all academic scientists and engineers in 1978 and 24 percent of all those employed in doctorate institutions. They accounted for 14 percent of the public institution S/E total and 18 percent of the private university S/E total. In addition, the study group accounted for 18 percent of the total change in S/E employment during the 1973-78 period.

Data Reliability

As part of the structured campus interviews questions were asked about the institutional record sources used to report data to NSF in the Survey of Scientific and Engineering Personnel Employed at Universities and Colleges. At all 23 institutions, the interviewees indicated that to the best of their ability, the personnel data were reported according to NSF survey instructions. Only in recent years, however, have institutions felt it necessary to maintain accurate records on the numbers and characteristics of their employees. In earlier years in the NSF data series, institutional personnel files were primarily maintained to meet payroll requirements. As social legislation for equal employment opportunities emerged, along with reporting requirements of Federal and State agencies, institutions began to maintain more extensive central records, by and large computerized, on various characteristics of their employees.

The greatest degree of inaccuracy in the data supplied to NSF was usually associated with decentralized reporting practices. In cases where institutions sent the NSF questionnaires to offices of graduate deans or department chairs, the turnover of staff who were assigned to complete the forms was particularly high from year to year. Consequently, subjective interpretations of survey requirements, varying greatly from one survey period to another, resulted in a lack of consistency in reporting trend data. Five of the 23 institutions in the sample had decentralized reporting procedures in the 1978 NSF survey period.

For the 18 institutions with centralized systems, the same reporting concepts were used throughout the institution, but these tended to vary from one institution to another, depending on how comprehensive the central files were in terms of the inclusion of professionals utilized in scientific activities. For example, in a number of the sampled institutions, not all postdoctorates were included in central payroll files since payments to some were made directly to the individuals by private foundations, Federal agencies, or other outside sponsors.

The present study and prior in-depth reliability and validity analyses by NSF indicate that a growing number of institutions are centralizing their reporting methods. As a result, there is a sound basis for concluding that the quality of institutional responses is improving and that improvements can be expected to continue in future survey cycles as centralized reporting practices progress.

The Data Base

The annual data bases resulting from the NSF-NIH Survey of Graduate Science Student Support and Postdoctorals were searched to identify institutions which offered doctoral programs in the sciences and/or engineering during the period from fall 1973 through fall 1976; 286 such institutions were identified. These 286 institutions were then checked against the survey populations of the NSF Survey of Scientific and Engineering Expenditures at Universities and Colleges for Fiscal Years 1973 through 1978 and the NSF Survey of Scientific and Engineering Personnel Employed at Universities and Colleges, January 1973 through 1978. These matched comparisons resulted in a total of 271 institutions in the data base comprising the statistical analysis shown in this report.

Because of expansion of survey coverage in 1974, only partial data were available for graduate science students and postdoctorates in 1972 and 1973. To estimate missing data on graduate science students and postdoctorates in 1972 and 1973 for this study, departments in the 1974 data base were matched with those in the two earlier years and the proportion of coverage in each year was compared with the 1974 data. These proportions were used to inflate the data in 1972 and 1973 on graduate science students and postdoctorates. This process resulted in a 22-percent increase in 1972 and a 20-percent increase in 1973 in the number of graduate science students in the data base. Corresponding adjustments to postdoctoral data were 29 percent in 1972 and 1 percent in 1973. The same procedure was used to estimate data for analyses pertaining to "distinguished" institutions. Rates of data estimation for these institutions were 20 percent in 1972 and 13 percent in 1973 for graduate science students; and 41 percent in 1972 and 3 percent in 1973 for postdoctorates.

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